Advanced Powertrain Technical Leadership Council Engine Benchmarking Group

Data Specification \ Engine Performance Testing

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11July2008
Version 1.1

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Background

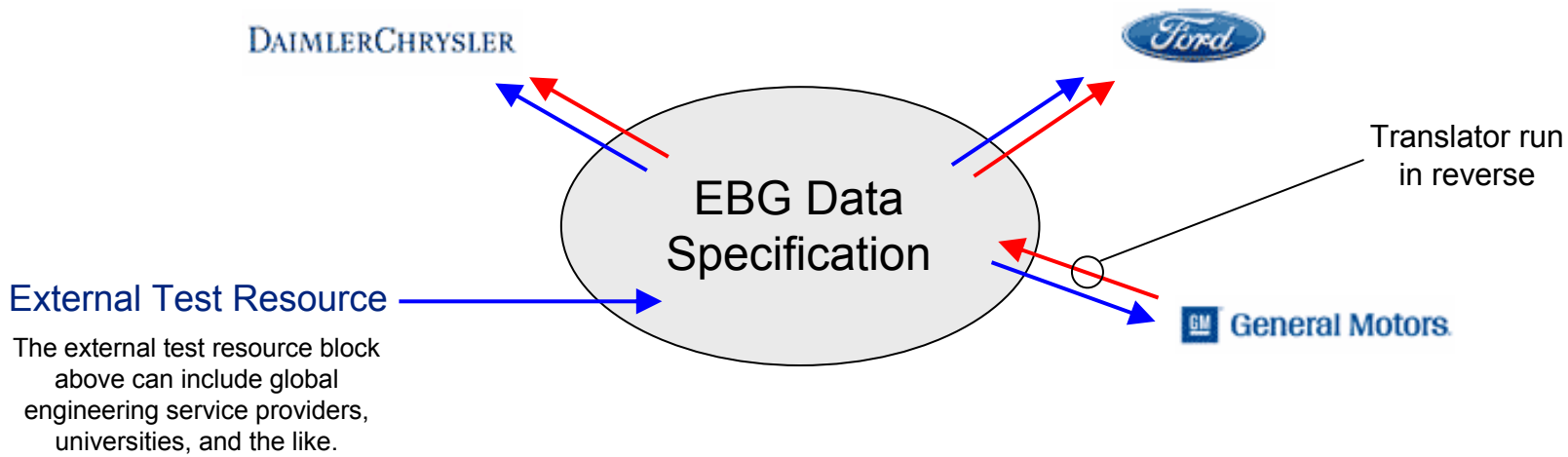
- The Advanced Powertrain Technical Leadership Council (TLC) Engine Benchmarking Group decided in February of 2005 that it would benefit by having a standard specification for sharing engine performance test data.
- A small Data Specification Team was created at that time with representatives from Ford, GM, and Chrysler.
- This document, and related files are the product of this Team's effort.

Introduction

- The Engine Benchmarking Group (EBG) Data Specification is intended to be the “common language” for all EBG partners to “speak”.
- It need have little / nothing in common with each partner’s internal data specification.
- The EBG Data Specification will allow each partner to create a “translator” which converts data following the EBG Data Specification to their respective internal data specification.
- Prior to the EBG Data Specification, the “translation” was either done by hand or not at all because of inconsistencies in the external data.
- With this specification, the translation of external data can be automated.
- This automation will reduce the time (i.e. cost) to get the external data into a useable form and will allow it to be more tightly integrated into each partner’s respective internal data systems.

Translator Concept

- The blue arrows in the graphic below show how a data set supplied from an external test resource would flow through the specification "translator" and to the partners.
- The red arrows show how the translator can be "run in reverse" when datasets are shared among the partners.



Scope

- What it is:
  - Names, descriptions, units, data format, file naming convention…
  - for 4-stroke gasoline engine dynamometer testing
  - It lends itself to grow / add new parameters…
  - Potential other / future uses are:
    - 2-strokes
    - Hybrids
    - Replacement for engine dimension summary
    - Diesel (fuel properties)
    - In-vehicle test data

Data Specification Files

- The Data Specification is comprised of three (3) files:
  - EBG Data Specification 1) Overview.ppt (this file)
  - EBG Data Specification 2) Parameter Details.xls
  - EBG Data Specification 3) Sample Data File.xls
- The last two files will be discussed in details in the following pages.

2) Parameter Details.xls (concatenation)

- The Parameter Details file has the information required to build a parameter name
- The file does not explicitly list all possible parameter names; it gives a convention on how to create parameter names
- Parameter types are categorized (name of Excel sheet) and sub-categorized (items listed on the Excel sheet)
- For each sub-category, parameter naming elements are defined (i.e. a,b,c,d values)
- Parameter short and long names are created by concatenating these elements with an underscore (i.e. a_b_c_d)
  - The long name is a verbose description (≤ 256 characters typical)
  - The short name will be displayed along with the tabular data (≤ 32 chars. typ.)

2) Parameter Details.xls (key1)

- Each Parameter sub-category will have the following elements defined:
  - Key - how many elements are used

Category 1:	Combustion
Category 2:	Burn / Heat Release Integrated values
Key:	a_b_c_d_e
Example:	HRBURN_10_90_EA_M

Key Definition	Short Name	Long Name	Units	Equation	Description
a =		**Base Parameter Name**			
	B	Burn duration for mass fraction burn using burn curve	deg	See BURN in MTS CAS manual revision C.	
	HRBURN	Heat Release percentage of burn duration	%	See MTS CAS manual revision C.	Calculates the percentage of burn duration based on heat release method based on start and end specified.
b =		**Starting percentage**			
	xx	Starting percentage			Starting percentage of mass fraction burned
c =		**Ending percentage**			
	yy	Ending percentage			Ending percentage of mass fraction burned
d =		**Parameter descriptor**			
	EA	Engine average			
	ELS	Engine lump sum			
	IMB	Engine imbalance			
	RMS	Root mean squared			
	xx	Cylinder number			
e =		**Parameter Statistic**			
	M	Mean			
	X	Maximum			
	N	Minimum			
	L	Lowest normalized value			
	S	Standard deviation			
	C	Covariance	%		

2) Parameter Details.xls (key2)

- Each Parameter sub-category will have the following elements defined:
  - Key - how many elements are used
  - Key Definition - what the a,b,c's represent

Category 1:	Combustion
Category 2:	Burn / Heat Release Integrated values
Key:	a_b_c_d_e
Example:	HRBURN_10_90_EA_M

Key Definition	Short Name	Long Name	Units	Equation	Description
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	HRBURN	Heat Release percentage of burn duration	%	See MTS CAS manual revision C.	Calculates the percentage of burn duration based on heat release method based on start and end specified.
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	yy	Ending percentage			Ending percentage of mass fraction burned
d =		**Parameter descriptor**			
	EA	Engine average			
	ELS	Engine lump sum			
	IMB	Engine imbalance			
	RMS	Root mean squared			
	xx	Cylinder number			
e =		**Parameter Statistic**			
	M	Mean			
	X	Maximum			
	N	Minimum			
	L	Lowest normalized value			
	S	Standard deviation			
	C	Covariance	%		

2) Parameter Details.xls (key3)

- Each Parameter sub-category will have the following elements defined:
  - Key - how many elements are used
  - Key Definition - what the a,b,c's represent, along with values for:
    - Description
    - Equation
    - Units
    - Long Name
    - Short Name

Category 1:	Combustion				
Category 2:	Burn / Heat Release Integrated values				
Key:	a_b_c_d_e				
Example:	HRBURN_10_90_EA_M				
Key Definition	**Short Name**	**Long Name**	**Units**	**Equation**	**Description**
a =		**Base Parameter Name**			
	B	Burn duration for mass fraction burn using burn curve	deg	See BURN in MTS CAS manual revision C.	
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	yy	Ending percentage			Ending percentage of mass fraction burned
d =		**Parameter descriptor**			
	EA	Engine average			
	ELS	Engine lump sum			
	IMB	Engine imbalance			
	RMS	Root mean squared			
	xx	Cylinder number			
e =		**Parameter Statistic**			
	M	Mean			
	X	Maximum			
	N	Minimum			
	L	Lowest normalized value			
	S	Standard deviation			
	C	Covariance	%		

2) Parameter Details.xls (example)

- An example name is also listed
- If there are statistics, they are listed as the last of the a,b,c elements
- Units are typically carried in only one of the a,b,c elements
  - Covariance is the notable exception, where the unit is percent

Category 1:	Combustion
Category 2:	Burn / Heat Release Integrated values
Key:	a_b_c_d_e
Example:	HRBURN_10_90_EA_M

Key Definition	Short Name	Long Name	Units	Equation	Description
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	RMS	Root mean squared			
	xx	Cylinder number			
e =		**Parameter Statistic**			
	M	Mean			
	X	Maximum			
	N	Minimum			
	L	Lowest normalized value			
	S	Standard deviation			
	C	Covariance	%		

2) Parameter Details.xls (categories and sub-categories)

- Combustion (any data logged by a combustion analysis system)
  - Burn / Heat Release Integrated values
  - Burn & Heat Release Crank Angle
  - Burn Duration
  - Knock
  - Pressure - Integrated Values or Maximums
  - Crank Angle Specific Measurements
  - Injection and Ignition timing
  - General - signals
  - General - test point
- ECU Parameters
- Fluid Properties
  - Fuel
  - Engine Coolant
  - Lubricating Oil
- Physical Properties
  - Temperature
  - Pressure
  - Sound Pressure
  - Humidity - Absolute
  - Vibration
  - Density
- Performance
  - Emissions and Induction
  - Torque/Power
  - Specific Emissions, Fuel Consumption
  - Efficiency
  - Rotating
  - Timing / Duration or Position

2) Parameter Details.xls (final)

- Questions can be submitted through USCAR website to the review board for modifications / adds…
- Provides a consistent methodology for creating parameter names

3) Sample Data File.xls

- Naming convention…
- One test per file
- Done in Excel
- Four basic tabs… expandable if needed to account for additional test parameters (>256)
- Tabs were broken down into use frequency.
  - Supplier Details – filled out once for test facility and equipment
  - Test Header – filled out once completely and updated for each test were needed
  - Test Data 1 – new every test
  - Test Data 2 – new ever test - used if more than 256 parameter

3) Sample Data File.xls \ Supplier (tab 1)

- General information on test facility and equipment.
- Fields are protected
- Data Type indicates whether it's a pick list, number, calc or free text field
- Filled out once unless equipment or location changes

	Data Type
Supplier Name	text

Test Facility Location

Street		text
City		text
State		text
Country		text
Postal Code		text
Elevation, meters		text
Cell Number		text

	Instrumentation Description	Manufacturer	Model Number	Additional Characteristics	
1	Fuel Flow Measurement System			e.g. volumetric	text
2	Combustion Analyzer				text
3	Dynamometer			e.g. water brake, eddy current	text
4	Load Cell				text
5	Engine Controller				text
6	Add as required for special instrumentation				text
7	e.g. Fast FID				text
19					text
20					text

= input information required in colored cells

3) Sample Data File.xls \ Test Header (tab 2)

- Test specific information
- Test and file name is concatenation of project code, test definition and type
- Fields are protected
- Data Type indicates whether it's a pick list, number, calc or free text field

input information required in colored cells =

Names below to be unique; may double as variable names in future.

Test Name		Data Type
Data File Name (name of this file)	MSU1WOTg_ECU_99	calc
Project Code (e.g. U-code for FEV, 4 characters or less)	MSU1	text
Test Definition	WOTg_ECU	calc
Test Type	WOTg	pick list
Engine Speed (rpm) **input if constant only**		number
Load (bmep - kPa) **input if constant only**		number
Control	ECU	pick list
Test Iteration Number (e.g. number of repeats)	99	number
Combustion Data	None	pick list
Dyno or Vehicle Test	Vehicle	pick list
Dyno Hours or Vehicle Mileage		number

Control Method for Calibratable Engine Parameters		
Fuel Delivery Method	Auto	pick list
Spark Delivery Method	Manual	pick list
Boost (forced induction only)	Not Applicable	pick list
Cam Lift Control	Not Applicable	pick list
Cam Phasing Control	Not Applicable	pick list
Charge Motion Control Valve Control		pick list
EGR Valve Control		pick list
Active Intake Control (e.g. tuning valve)	Auto	pick list
Active Exhaust Control (e.g. tuning valve)		pick list
Cylinder Deactivation		pick list
User Defined 1		pick list
User Defined 2		pick list
User Defined 3		pick list

3) Sample Data File.xls \ Test Data (tab 3)

- Data to be reported in Microsoft Excel
- 1st data column always to be an integer sample number
- 2nd column should be a date / time stamp (Microsoft compatible floating point number, e.g. 38698.153777662)
- Data will be in column format with no additional formatting required; can use default Excel column width.
- If more than 254 parameters, create a new sheet.
- 1st sheet is Test Data1; if adding sheet, inc last digit by one.
- 1st row is parameter name
- 2nd row is units
- 3rd row and lower are the data

3) Sample Data File.xls \ Test Data (tab 3)

- Record and report all data at maximum resolution available. The intent is not to specify the precision required for all of the instrumentation, but rather we don't want to lose any precision / resolution.
- Leave formatted as general.
- Reported units are to be as specified in "080617 EBG Data Specification 2) Parameter Details.xls" file.

Disclaimer

- For general equations of combustion parameters please refer to the MTS CAS manual revision C. USCAR is not promoting or excluding any one combustion analysis system. MTS CAS nomenclature was used in the creation of the combustion parameter list due to all parties present using similar versions of this system.